116 Visual Fields

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Definition

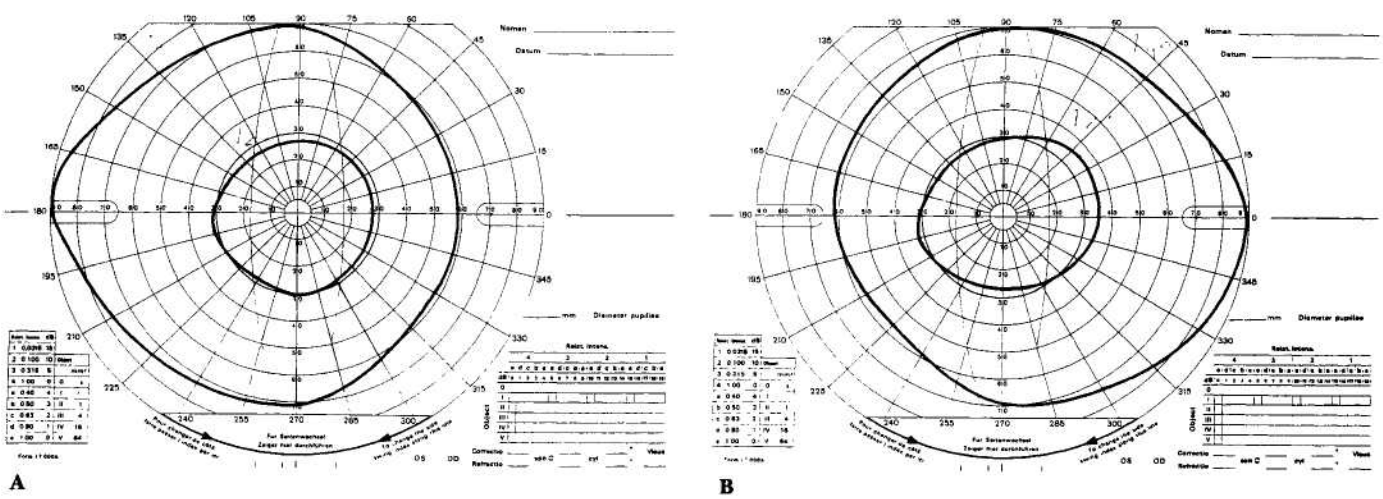
The field of vision is that portion of space in which objects are visible at the same moment during steady fixation of gaze in one direction. The monocular visual field consists of central vision, which includes the inner 30 degrees of vision and central fixation, and the peripheral visual field, which extends 100 degrees laterally, 60 degrees medially, 60 degrees upward, and 75 degrees downward (Figure 116.1) A vertical line bisects central fixation and divides the visual field into a nasal and temporal hemifield. Situated in the temporal hemifield is the normal blind spot approximately 12 to 17 degrees from fixation and 1.5 degrees below the horizontal meridian. The blindspot is represented on a visual field chart by an absolute scotoma and corresponds anatomically to the scleral canal through which the retinal nerve fibers leave the eye at the optic disk.

A normal visual field is an island of vision measuring 90 degrees temporally to central fixation, 50 degrees superiorly and nasally, and 60 degrees inferiorly. Visual acuity increases from movement discrimination in the extreme peripheral vision to better than 20/20 in the center of vision. Depression or absence of vision anywhere in the island of vision is abnormal.

Technique

A *perimetrist* is a person who measures the visual field with a machine called a *perimeter*. Various perimetric techniques and apparatus are available. In each form of testing, however, including confrontation field testing, patients must be continually urged to maintain steady fixation straight ahead while objects of varying size, color, or luminosity transcend their visual threshold. With kinetic perimetry, objects are moved from outside the boundary of visual perception toward fixation. When the patient perceives the particular test object, a set of visual threshold points are plotted by the perimetrist. The line that connects these similar visual thresholds is called an *isopter*. In Figure 116.1, the large oval circle indicates that the target I-4e was seen at all these points of the visual field during steady gaze on central fixation. A smaller target (I-2e) subtends a smaller amount of visual field. A Goldmann perimeter utilizes different-type targets that can be varied according to size and light intensity. The larger or brighter objects are perceived in the periphery while smaller targets outline boundaries and defects of the central visual field. *Depression* of the visual field, defined as an inward shift of a particular isopter, is depicted in Figure 116.2. If all the isopters show similar depression to the same point, it is then called a *contraction* of visual field. In local contraction, only part of the field including the periphery is restricted; but in concentric contraction, the entire peripheral vision is attenuated.

There is a great variety in both the methods and apparatus used for evaluating fields of vision. Quantified visual field testing with either a Goldmann perimeter or a tangent screen is ideal but may be impractical or impossible in a great many situations. Patients may be too ill to be moved to the machine and testing rooms, and children and aphasic or demented subjects certainly cannot comply with the examiner's complicated directions. For these situations, it is



A B

Figure 116.1
Normal visual field. I-4e is a larger target than I-2e.

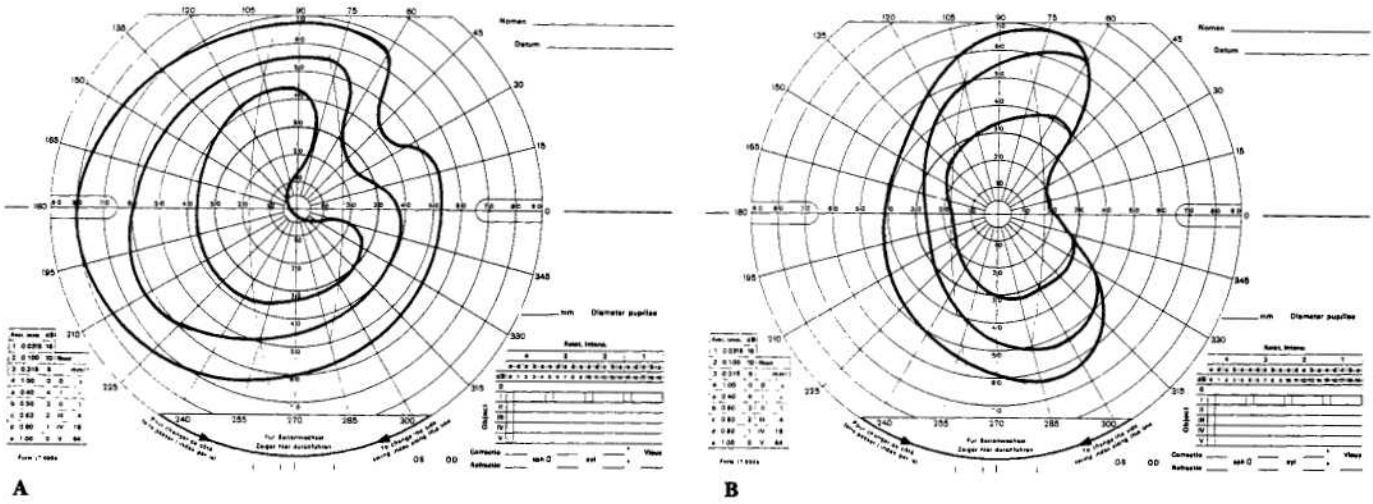


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Figure 116.2
(A) Depression of the upper nasal isopters. *(B)* Contraction of the temporal field.

essential to master the techniques of confrontation visual field testing.

Each eye should be tested individually in four steps:

1. Ask the patient to look at your nose and count fingers held briefly in the area of central fixation.
2. Move and flash your fingers in each of the four quadrants of vision, simultaneously encouraging the patient to maintain fixation on your nose. It is best to flash only one, two, or all five fingers because three and four fingers are difficult to distinguish.
3. To depict double simultaneous sensory stimulation, hold your hands about 18 inches (45 cm) apart and flash fingers simultaneously in the nasal and temporal hemifields. Again, the patient must maintain fixation. A number of permutations should be tried. For instance, with the patient's right eye fixing, raise one finger with your left hand and two fingers with your right hand; then hold up two fingers with your left hand and one on the right. If the patient first sees only one finger and then in the second part of the test sees only the hand with two fingers, you may suspect a nasal field defect of the right eye.
4. Hold both hands in the hemifield under suspicion (in this case, the nasal field of the right eye) and flash the fingers above and below the horizontal meridian, thereby testing the upper and lower portions of the affected field of vision.

The methods used to explore visual field defects in younger patients are similar to those used in adults who are dysphasic, illiterate, or obtunded. The human face is an excellent fixational target. One of our most primitive visual reflexes is to bring interesting fixational targets into central fixation. This fixational reflex may be put to use by observing an individual's eye movements as the examiner's face enters the visual field along different meridians.

Color perception is a more refined and more sensitive parameter of visual field function. The relative lack of color perception in one eye or in one-half of the visual field may be the salient manifestation of an active or resolved intracranial lesion. On the wards or in an emergency room, a qualitative assessment of color vision may be obtained by asking the patient to compare the richness or brightness of a primary color shown first to the right eye and then to the left. A patient with a central or cecocentral scotoma, due to an optic nerve lesion, will usually report that the colored objects appear dimmer, duller, or not as bright in the affected eye.

A comparison of brightness or richness of color can also be used to assess nasal versus temporal field perception. Each eye is tested individually. In order to explore the possibility of an hemianopic defect, two similarly colored objects are held before the patient with one in the nasal and the other in the temporal zone of vision. The patient, instructed to maintain fixation on the examiner's nose, tells whether the two objects look the same or whether one appears brighter or duller than the other. The object in an intact hemifield will usually be described as brighter or richer in hue; perception of a darker or duller object presents a potential zone of defective sight that should be further explored by moving the target from the area of relatively poor saturation into the brighter area. As this is done, the patient is asked to identify the exact point at which the moving object becomes as bright as the companion stimulus. The point of transition is carefully noted. If it lines up with an imaginary line drawn through the point of fixation, it is highly probable that the area of color desaturation represents a subtle hemianopic field defect. Areas of dull perception should always be explored by moving the test stimulus slowly into zones of brighter experience. In this manner, a careful and patient clinician may detect small hemianopic, quadrantic, and even cecocentral field defects.

The tangent screen is a black felt screen on which radial lines and 5-degree concentric circles are inconspicuously marked. It is used to examine the central field within 30 degrees from fixation and to determine the size of the blind spot. Because the papillomacular bundle forms 90% of all the optic nerve axons, and subserves the central 30 degrees of vision, the tangent screen is an excellent tool for evaluating neurologic-type field defects. The examiner stands in front of the patient to observe fixation and works from each side of the screen in turn. White or colored targets are fitted onto wands, which are slowly moved from outside visual perception toward fixation. Although great versatility is a part of this technique, a distinct disadvantage is also obvious:

The examiner's arm and body can be a distraction to a patient who is trying to concentrate and maintain fixation on a small white target.

The hemispheric projection perimeter (Goldmann perimeter) is a precise and popular instrument for testing both the peripheral and central portions of visual field. It affords a remarkable speed of operation for kinetic perimetry and luminence of the hemispheric background can be kept precisely controlled to keep retinal light adaptation constant. Fixation is maintained by the perimetrist through a telescope which is a more accurate method than used with the tangent screen. Projected spots of constant size and fixed contrast are moved from the periphery in toward the center.

Basic Science and Clinical Significance

Topical Localization of Visual Field Defects

To interpret the results of perimetry accurately, the reader must firmly understand some basic neuroanatomy of the visual pathway. The primary visual sensory pathway in humans consists of the retina, optic nerves, chiasm, and optic tract, along with the lateral geniculate bodies, geniculocalcarine radiations, and the occipital cortex. Secondary complex nerve fiber systems connect the occipital striate cortex with the ipsilateral and contralateral visual association areas.

The retina is a well-differentiated stratified sensory membrane. Incident light eventually stimulates the ganglion cell layer of the retina and axons from ganglion cells course toward the optic disk in three basic patterns: a papillomacular bundle, which arises from the macula or central point of the retina, superior and inferior arcuate bundle, which comes from the temporal retina, and radial fibers from the nasal retina (Figure 116.3). An imaginary vertical and horizontal line through the macular anatomically divides the retina into nasal/temporal, superior/inferior halves, respectively. Nasal axons subserve the temporal half of vision, temporal axons the nasal hemifield, superior axons the lower visual field, and inferior axons the superior visual field.

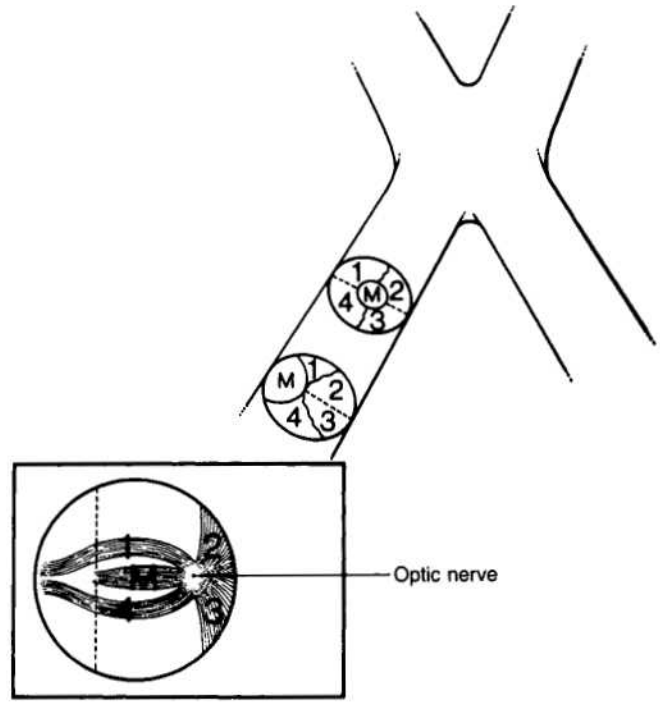

Figure 116.3
Retinal nerve fibers: M, papillomacular bundle; 1,4 superior and inferior arcuate bundles; 2,3 superior and inferior nasal fibers.

The papillomacular bundle represents more than 90% of all the retinal nerve fibers in the optic nerve. It projects images from the macula and functions to maintain sharp focus of central fixation. Lesions that interrupt the papillomacular bundle produce central or cecocentral scotomas (Figure 116.4). A scotoma is an area of poor vision sur-

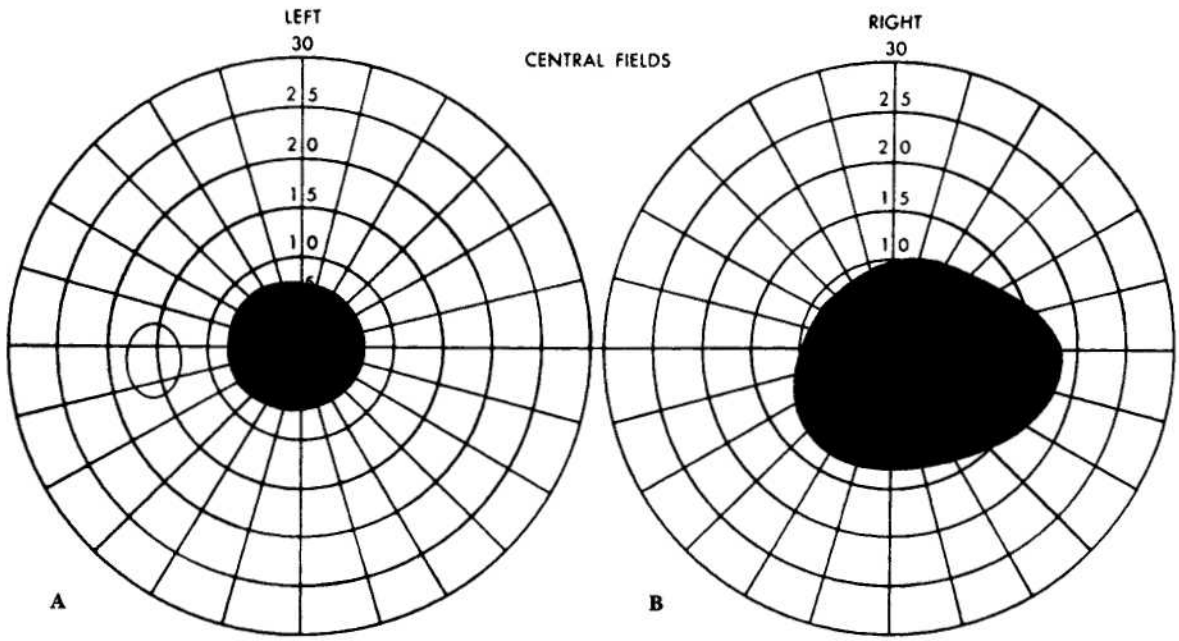

Figure 116.4
(A) Central scotoma. *(B)* Cecocentral scotoma.

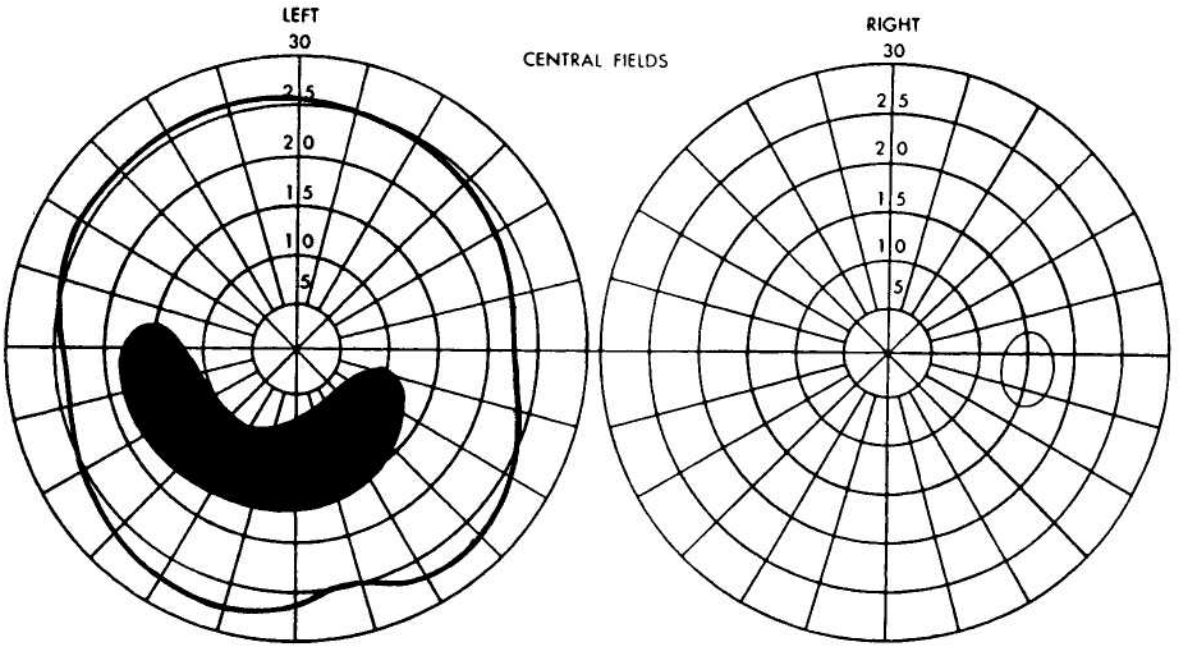

Figure 116.5
An inferior arcuate scotoma.

rounded on all sides by relatively better vision. The arcuate fibers surround the papillomacular bundle, originating above, below, and temporal to it. Lesions of the arcuate bundle produce arcuate or cuneate-shaped scotomas (Figure 116.5). Damage to the superior arcuate bundle, for instance, in glaucoma, manifests as an inferior arcuate scotoma.

Lesions of nasal retinal axons cause temporal field defects. If the nasal axons nearest the macula are spared, the resulting field defect shows sparing of the parafixational temporal hemifield (Figure 116.6). But if the nasal fiber components of the papillomacular and arcuate fibers are involved, a temporal hemianopia is noted. All of the involved temporal field is affected; hence, the field defect abuts up against the vertical meridian (Figure 116.6B). Intracranial lesions of the optic chiasm and retrochiasmal visual pathway produce hemianopia, that is, visual field defects which "respect" the vertical meridian.

Optic Chiasm

All the nasal retinal fibers decussate in the optic chiasm (Figure 116.7). But the inferior nasal fibers turn rostrally into the opposite optic nerve before projecting back into the opposite optic tract. This anterior elbow of inferior nasal axons into the opposite optic nerve is called Von Willebrand's knee. Lesions of the *posterior* optic nerve where it joins with the optic chiasm will produce impaired vision in the ipsilateral eye and an upper temporal field loss in the

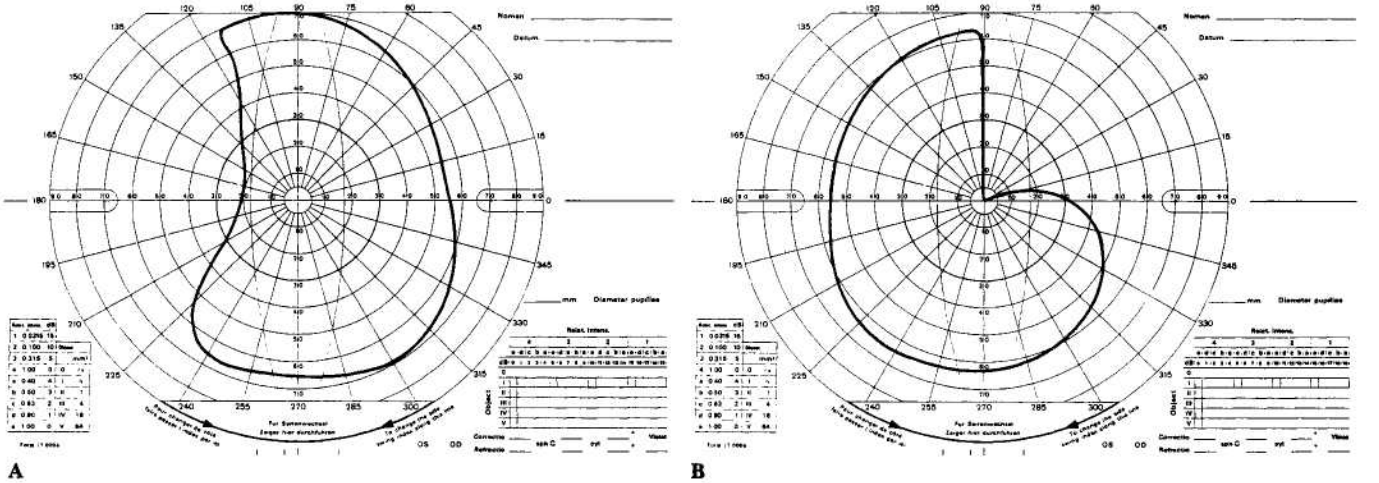

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Figure 116.6
(A) Depression of the temporal field. *(B)* An upper temporal quad-rantanopia.

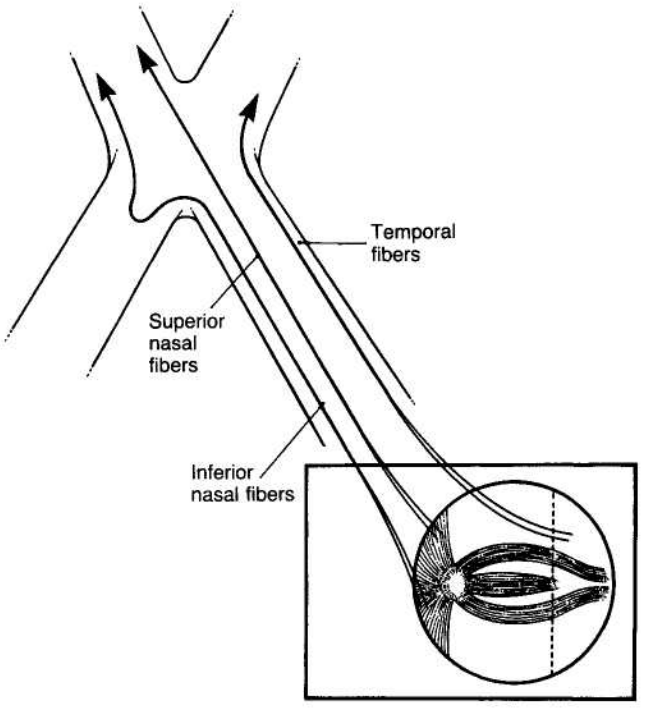

Figure 116.7
Note anterior angulation of crossing inferior nasal fields before they project posteriorly to form optic tract. Superior nasal fibers cross directly to opposite side and align with uncrossed superior and inferior temporal retinal fibers.

contralateral eye (Figure 116.8), a syndrome referred to as a junctional scotoma.

Damage to the body of the optic chiasm itself produces bitemporal hemianopia (Figure 116.9). Lesions of the optic tract produce homonymous hemianopia; specifically, incongruous homonymous hemianopia (Figure 116.10). Incongruity refers to asymmetry of the visual field defects. Within the optic tract the crossing nasal fibers and the uncrossed temporal fibers are relatively separated anatomically. Hence, corresponding points of the visual field from each eye are not closely aligned. Visual field loss from lesions of the optic tract or the lateral geniculate body affect each eye differently (Figure 116.10), resulting in asymmetric field loss in each eye. Retrogeniculate homonymous field defects are almost always congruous or exactly alike because the nasal and temporal fibers from corresponding points in the visual field are closely opposed.

Optic Tract

Optic tract fibers synapse at the lateral geniculate body and project backward as the geniculo-calcarine radiations. All the retrogeniculate fibers sweep laterally and inferiorly around the temporal horn of the lateral ventricle. The most anterior-inferior fibers form Meyer's loop, which contains projections of the inferior retinal fibers. Hence, lesions of Meyer's loop, located primarily in the temporal lobe, produce congruous, superior homonymous quadrantanopias (Figure 116.11); more superiorly located parietal lobe lesions produce the inverse defects, inferior homonymous hemianopias or quadrantanopias.

Visual Cortex

The striate or primary visual cortex of humans occupies the medial and posterolateral surfaces of the occipital lobe. Striate cortex can be found above, below, and even within the walls and floor of the calcarine fissure itself. Topographically, the central or parafixational zone of each hemifield is subserved by retinal axons that eventually terminate at the most

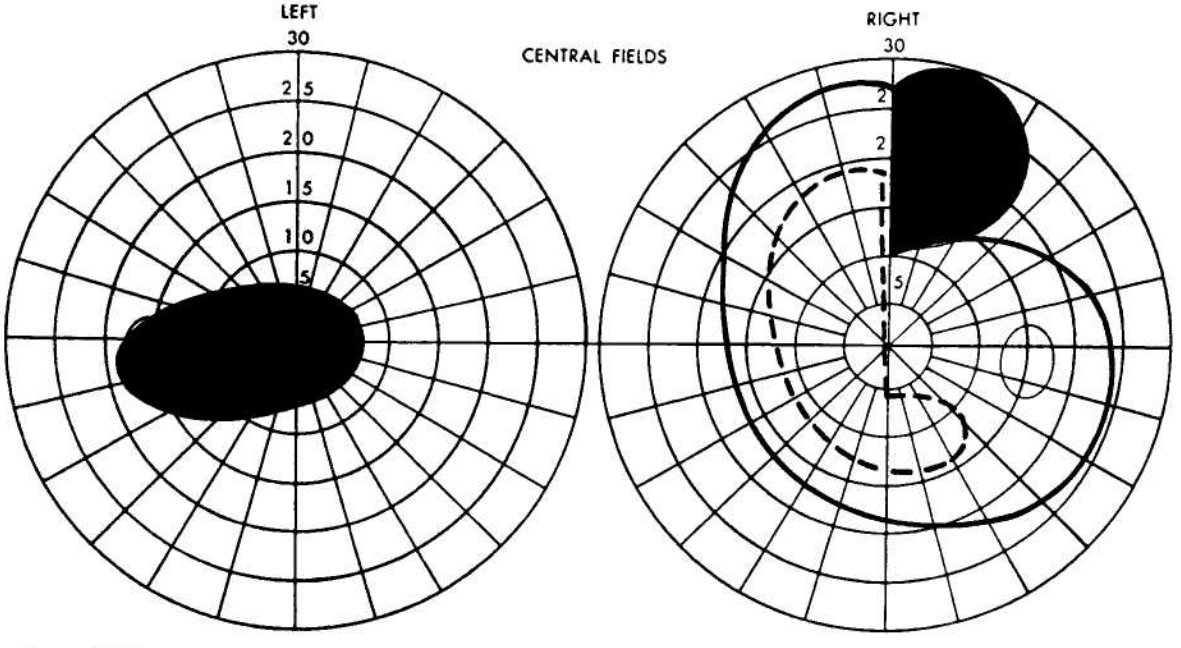

Figure 116.8
Junctional scotoma, a cecocentral field defect in one eye along with an upper temporal quadrant defect in the other eye.

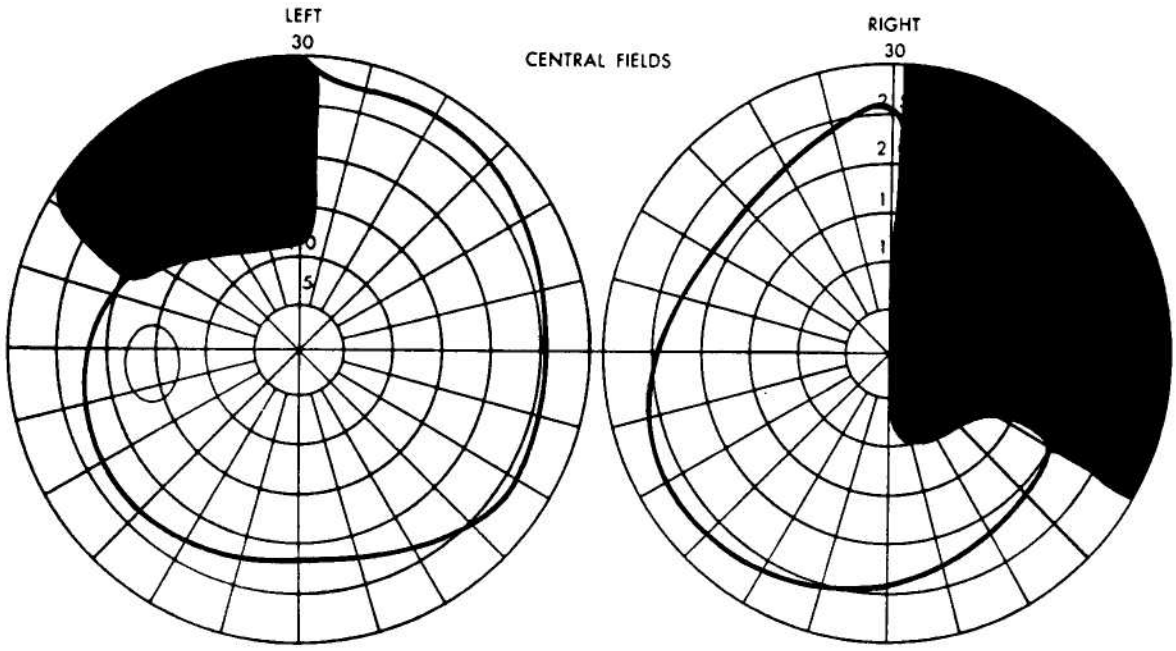

Figure 116.9
Bitemporal hemianopia.

posterior pole of the visual cortex. A lesion here will produce a homonymous, paracentral hemianopic scotoma. Such defects involve the central 5 to 10 degrees of vision and may spare the remainder of visual field if the remainder of the striate cortex is spared (Figure 116.12). The opposite-type field defect, a homonymous hemianopia "with macular sparing," occurs with occipital lesions that spare the posterolateral striate cortex (Figure 116.13).

The peripheral portion of each hemifield, which includes the temporal monocular crescent, projects to the anterior lip of the calcarine fissure. Lesions that spare the anterior cortex will cause homonymous hemianopias with sparing of the peripheral hemifield or temporal crescent. The temporal crescent is a 30-degree segment of temporal field that begins 60 degrees from fixation. It is entirely unshared and monocular (i.e., seen by one eye only). These nasal retinal axons decussate in the optic chiasm and terminate at the most anterior occipital cortex. Focal damage here could theoretically produce a monocular visual field defect that only involves the temporal crescent of the contralateral eye. Sparing of the temporal crescent, on the other hand, in the presence of a congruous homonymous hemi-

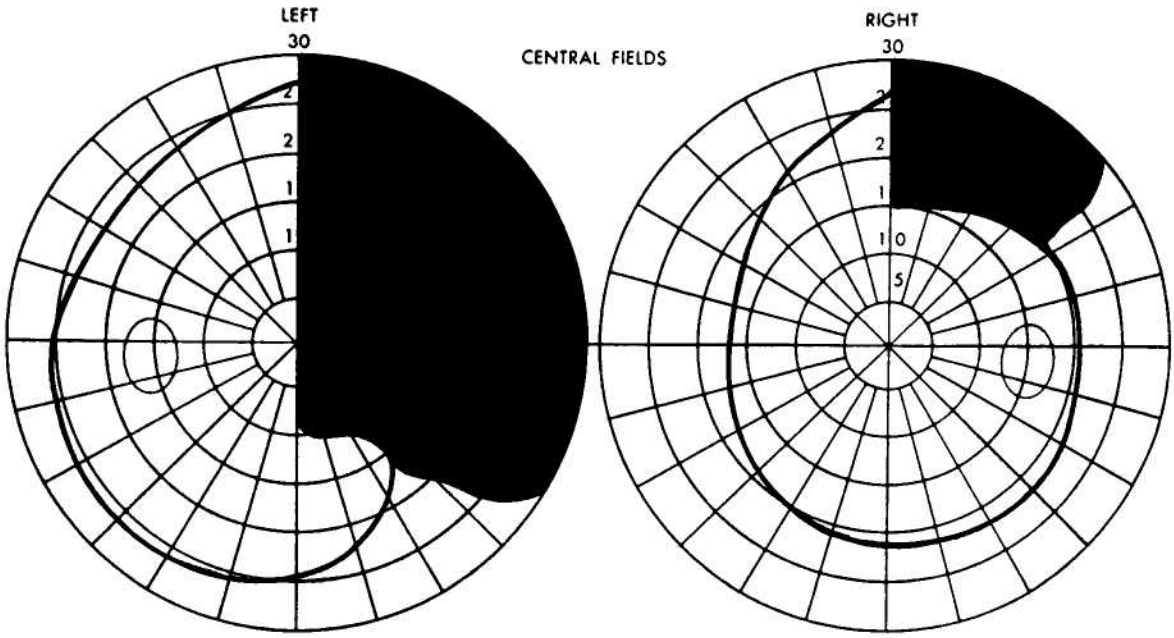

Figure 116.10
Incongruous right homonymous hemianopia.

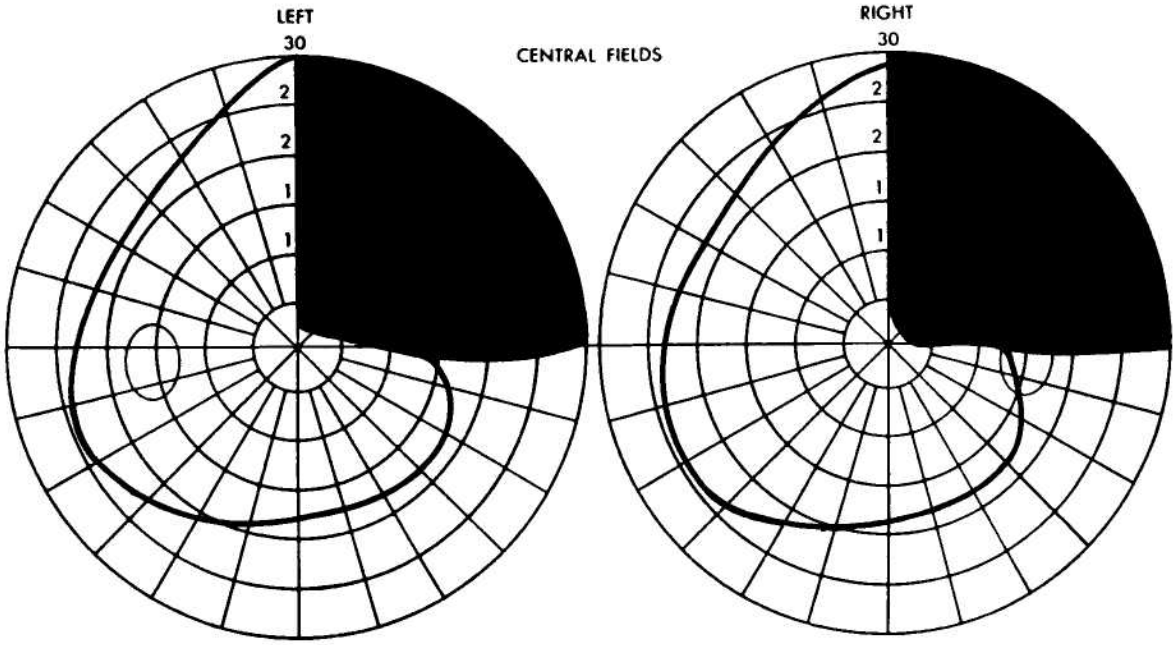

Figure 116.11
Congruous right homonymous hemianopia.

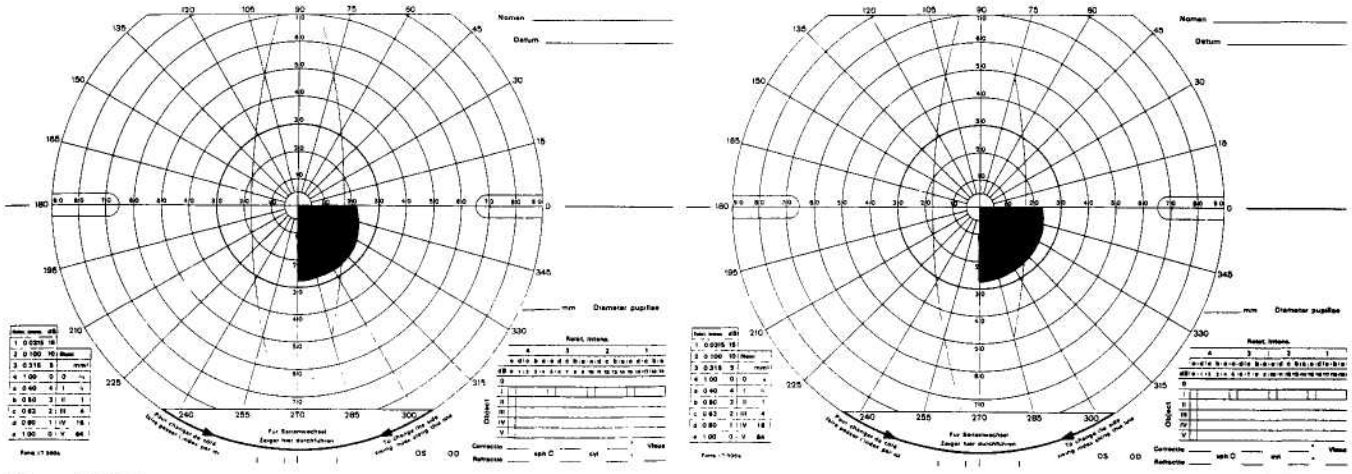

Figure 116.12
Right homonymous, paracentral hemianopic scotoma.

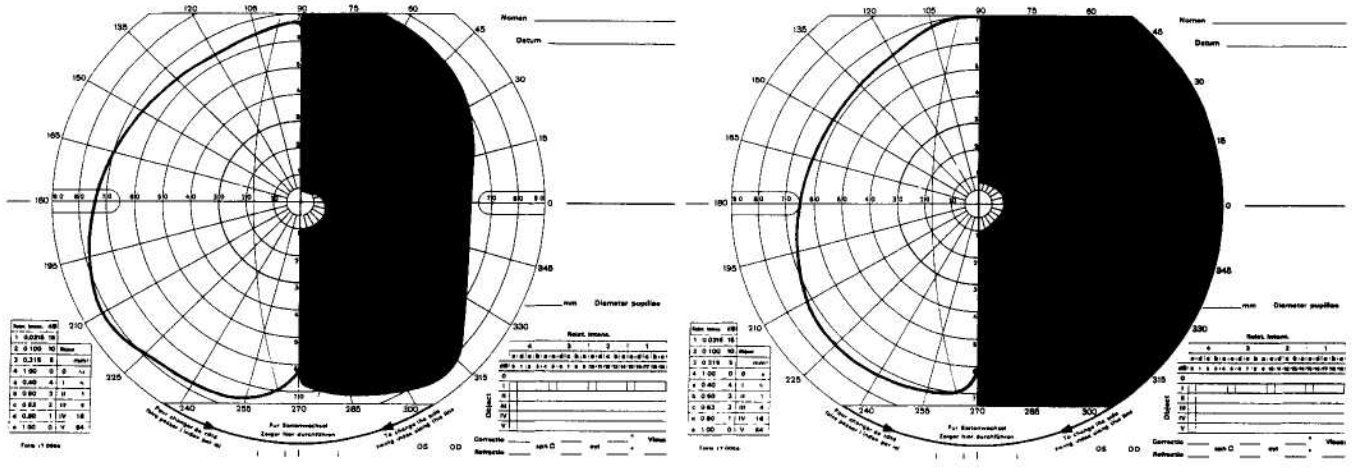

Figure 116.13
Right homonymous hemianopia with sparing of central fixation.

anopia permits exact localization of the site of the lesion to the contralateral posterior occipital cortex.

Bilateral homonymous hemianopsias result from bilateral, usually ischemic lesions of the visual cortices. If each homonymous field defect involves the parafixational zone, the combined defects lead to a central scotoma and loss of central vision. Cortical blindness is characterized by (1) symmetric loss of visual acuity, (2) relatively normal pupils and fundal structures, (3) denial of blindness, and (4) bilateral occipital–cortical lesions.

Accurate visual field testing and an intelligent interpretation of the results can provide the wary examiner with extremely useful information regarding the site and sometimes the exact histologic type of lesion. Because the visual sensory pathway of humans spans the brain from front to back, visual field abnormalities are present in a wide variety of CNS and orbital disorders. Some of these include orbital and parasellar tumors, the amenorrhea-galactorrhea syndromes, diabetes insipidus, multiple sclerosis, starvation, administration of certain drugs (e.g., ethambutol), cerebrovascular disease, and many more. The reader should be able to apply these principles now to the day-to-day evaluation of neurologic and ophthalmologic problems.

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